DIVISION OF ENVIRONMENT
QUALITY MANAGEMENT PLAN

PART III:

STREAM BIOLOGICAL MONITORING PROGRAM
QUALITY ASSURANCE MANAGEMENT PLAN

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Section 1

INTRODUCTION

1.1 Purpose of Document

This document presents the quality assurance (QA) management plan for the Kansas stream biological monitoring program. Quality assurance goals, expectations, responsibilities, and program evaluation and reporting requirements are specifically addressed. Standard operating procedures (SOPs) for the collection, preservation, examination and archival of biological specimens and the gathering of ancillary field data are provided in the appendices of the plan.

1.2 Basic Principles

Freshwater macroinvertebrate communities, consisting of insects, crustaceans, mollusks, annelids and other organisms which lack a true backbone and are observable with the unaided eye, have long been recognized as excellent indicators of water quality (Gaufin 1973; Weber 1973; Patrick 1977; Dance and Hynes 1980; Reger and Kevern 1981; Wynes and Wissing 1981; Whiting and Clifford 1983; Pederson and Perkins 1986; Taylor and Roff 1986; Plafkin *et al*. 1989; Rosenberg and Resh 1993; Davis and Simon 1994; Loeb and Spacie 1994; Merrit and Cummins 1996; Karr and Chu 1999). Utilization of macroinvertebrate communities in water quality assessments offers several advantages over the use of other aquatic organisms or reliance on physicochemical measurements alone:

(1) Collection of macroinvertebrate specimens requires little specialized equipment and entails a relatively small commitment of staff and other resources.

(2) Macroinvertebrate species differ in their physiological tolerances to contaminant exposure. A knowledge of the taxa comprising a macroinvertebrate community, coupled with an understanding of the tolerances of individual taxa, provides a highly discriminatory assessment tool.

(3) Many aquatic macroinvertebrates live for several months or years and almost all spend the majority of their lives in the water. Hence, macroinvertebrate communities provide an integrated measure of water quality over a relatively long period of time.

(4) Although movement of certain types of macroinvertebrates does occur, primarily in the form of drift, long-term import and export rates are generally similar and the continuity of the community is normally maintained (Bird and Hynes 1981; O'Hop and Wallace 1983). Relative to the more mobile organisms, such as fish, macroinvertebrates tend to provide a clearer indication of prevailing water quality conditions within a given stream reach.

(5) Most macroinvertebrate communities contain herbivorous, carnivorous and detritivorous species (Merritt and Cummins 1996). Changes in the relative abundance of these feeding groups may be used as an indicator of the effect of water pollution on trophic relationships (food web interactions) among species.

Ongoing pollution problems, whether continuous or intermittent in nature, tend to reduce in abundance the more pollution intolerant species. Conversely, tolerant forms often achieve unusually high densities due to reduced interspecific competition for food, elimination of predators, and other factors. The predictable community-level response to environmental pollution is, therefore, an increase in the abundance of tolerant taxa and, at higher pollutant loadings, a measurable decrease in species richness (Hynes 1960). Where macroinvertebrate sampling is used in conjunction with physicochemical monitoring activities (see Kansas stream chemistry monitoring program QA management plan), the ability to detect ongoing water quality problems is greatly enhanced, even at low biological sampling frequencies.

1.3 Historical Overview of Program

1.3.1 Development of Monitoring Network and Sampling Protocols

The stream biological monitoring program was initiated by the Kansas Department of Health (later reorganized into the Department of Health and Environment or KDHE) in April 1972. Approximately 33 stream stations, located at widely scattered locations across the state, were included in the original monitoring network. The initial goals of the program were to document long-term trends in surface water quality and to supplement site-specific information then being gathered through other departmental monitoring efforts (e.g., intensive river basin surveys).

During the first six years of the program, field protocols entailed a combination of qualitative and quantitative sampling techniques at all stream monitoring stations. Qualitative methods included the collection of macroinvertebrate specimens from all accessible microhabitats using D-frame nets and other simple apparatus. Quantitative methods, focusing on the density of macroinvertebrate populations, varied depending on the predominate substrate type. A Surber sampler generally was used on coarse sediments such as cobble and gravel, whereas a petite Ponar dredge was used on finer sediments such as sand and silt. These tools were not well suited to the sampling of woody debris, tree roots, emergent aquatic vegetation, or other nonhomogeneous surfaces, even though such habitats accounted for much of the macroinvertebrate abundance and diversity in many Kansas streams. Hence, early quantitative measures of macroinvertebrate abundance and diversity employed by the agency tended to underestimate the actual size and complexity of stream biological communities.

In 1978, the monitoring program adopted a revised protocol for the collection of macroinvertebrate samples (Appendix B). This new protocol was a time-based "equal effort" quantitative technique. It measured the number of specimens collected in a prescribed (one person-hour) time frame using D-frame nets and other tools previously associated with strictly qualitative sampling activities. Emphasis on the number and kinds of specimens collected per unit time (rather than on aerial or volumetric estimates of macroinvertebrate density predicated on the use of Surber samplers and Ponar dredges) permitted the examination of essentially all types of stream habitat. The revised protocol proved to be less resource intensive and produced a more consistent measure of macroinvertebrate abundance and diversity. Similar protocols were eventually endorsed by the United States Environmental Protection Agency (EPA) and applied within the water quality assessment programs of several other states (see Rapid Bioassessment Protocol III in Plafkin *et al*. 1989). In 1990, field staff also began to routinely record observations of any living unionid mussels encountered at stream biological monitoring sites, whether or not these organisms were actually included in the quantitative samples. Staff also began to make representative collections of any encountered (freshly dead, weathered or relict) shell materials to provide an indication of any recent or historical changes in the composition of the unionid mussel community (Appendix B).

Although macroinvertebrate sampling activities at many of the original monitoring stations were eventually discontinued, new sites were continually added to the network and, over time, the total number of active monitoring stations increased. Macroinvertebrate communities were surveyed at 68 monitoring stations during the period 1996-2000, and 57 stations were sampled in 2000 alone. As of January 2001, 178 stations had been sampled at least once, 98 stations had been sampled for a duration of at least three years, and 78 stations had been sampled for a period of 4-21 years. From 1984 onward, as climatic conditions permitted, most monitoring activities adhered to a seasonal rotational schedule to reduce statistical bias and provide a more comprehensive picture of the resident macroinvertebrate communities; i.e., samples were collected during the spring of one year, the summer of the next, and the fall of the next, a cycle which was repeated every three years.

During the period 1994-1996, samples were obtained from six relatively unpolluted locations or "reference sites" on a quarterly schedule and from one reference site on a monthly basis. During the period 1999-2000, additional reference sites were added to the monitoring network for the reasons discussed in section 4.1, below. Monitoring operations at most other stations have adhered to the seasonal rotational approach described above. Figure 1.3.1-1 depicts the geographical distribution of all stations in the stream biological monitoring network sampled between 1980 and 2000. Figure 1.3.1-2 depicts the distribution of those stations sampled between 1996 and 2000.

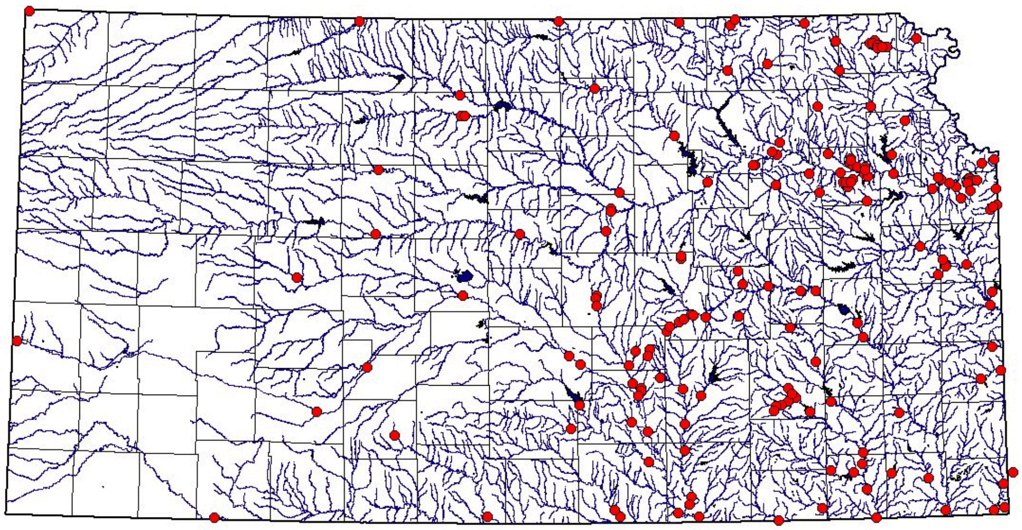

Figure 1.3.1-1. Distribution of KDHE stream biological monitoring stations, 1980-2000.

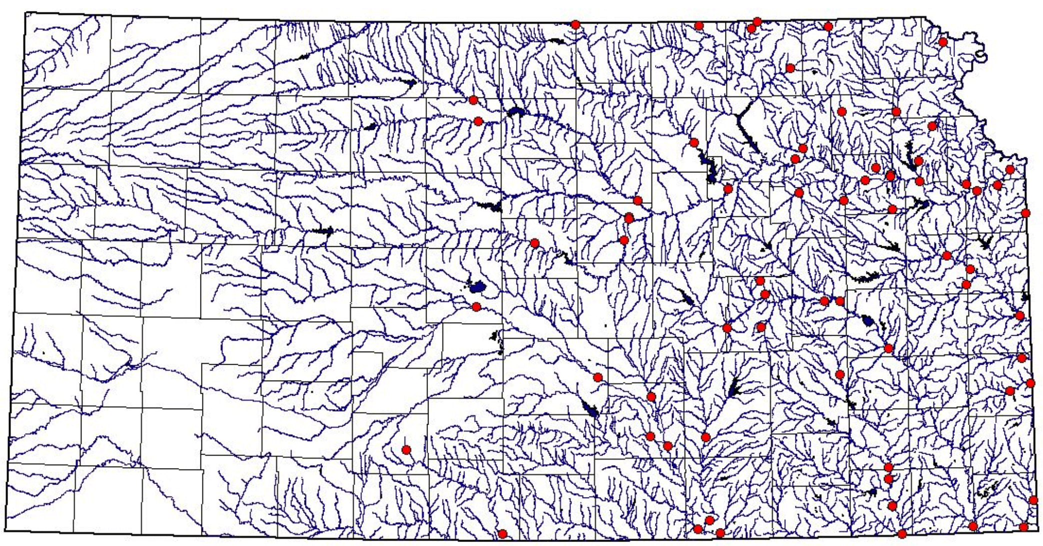

Figure 1.3.1-2. Distribution of KDHE stream biological monitoring stations, 1996-2000.

1.3.2 Development of Taxonomic Capabilities

The past two decades witnessed a dramatic improvement in science's understanding of the North American and regional macroinvertebrate faunas. Several comprehensive taxonomic works, new and revised, were published during this period (Appendix D). In Kansas, the basic composition of the state's macroinvertebrate fauna was elucidated by the State Biological Survey of Kansas (SBSK), and a number of taxonomic keys were developed for the more common families, genera and species of aquatic insects (Appendix D). These developments allowed personnel of the stream biological monitoring program to more accurately monitor the composition of macroinvertebrate communities within the state and, therefore, to apply more sophisticated statistical techniques in the evaluation of surface water quality (see section 1.3.3, below). Although the program's taxonomic capabilities developed in a generally continuous and cumulative manner, the chronology of this developmental process involved at least three discernable phases:

(1) 1972-1978 - Most macroinvertebrate specimens collected from 1972 to 1976 were identifiable only to the taxonomic level of order or family. From 1977 to 1978, an increasing number of taxonomic assignments were made at the generic level. Collection methodologies during this period did not yield samples of high diversity, and only the most abundant taxa were consistently collected. The systematics of certain major groups (e.g., annelids and midges) were poorly developed at this time. In general, the available taxonomic literature and limited knowledge of the regional fauna did not permit greater resolution of macroinvertebrate assemblages. The principal taxonomic keys in use during this period were: "Freshwater Invertebrates of the United States" (Pennak 1953); "Aquatic Insects of California" (Usinger 1956); and "Freshwater Biology" (Edmondson 1959).

(2) 1979-1982 - A reference collection of macroinvertebrate specimens was started by the department in 1979 and grew rapidly over the next several years. Many of these reference specimens were identified or independently verified by experts at SBSK. Several important taxonomic keys were published during this period, and many additional faunal groups were identifiable at the generic or species level (Table 1.3.2-1). Indeed, virtually all members of the dragonfly suborder Anisoptera, the caddisfly family Hydropsychidae, the beetle family Elmidae, and the mayfly genus *Stenonema* were identifiable to species. Only a few difficult or obscure faunal groups (e.g., annelids) continued to receive taxonomic assignments at the order or familial level.

TABLE 1.3.2-1
PRINCIPAL TAXONOMIC REFERENCES USED FROM 1979 TO 1982

Comprehensive Taxonomic Literature	
"Aquatic Insects of California"	(Usinger 1956)
"Aquatic Insects of Wisconsin"	(Hilsenhoff 1975)
"Aquatic Insects of North America"	(Merritt and Cummins 1978)
"Freshwater Invertebrates of the United States"	(Pennak 1978)
Literature for Specific Taxonomic Groups	
Turbellaria	(Kenk 1972)
Hirudinea	(Klemm 1972; Klemm 1982)
Oligochaeta	(Hiltunen and Klemm 1980)
Tubificidae	(Stimpson *et al*. 1982)
Bivalvia	(Murray and Leonard 1962; Burch 1972, 1973)
Gastropoda	(Leonard 1959; Burch 1982)
Crustacea	(Hobbs 1972; Holsinger 1972)
Isopoda	(Williams 1972)
Coleoptera	(Brown 1977)
Diptera	(Mason 1973; Beck 1976)
Ephemeroptera	(Burks 1953; Lewis 1974; Bednarik and McCafferty 1979)
Hemiptera	(Hungerford 1954)
Odonata	(Needham and Westfall 1954; Cannings 1981)
Plecoptera	(Stark and Gaufin 1976)
Trichoptera	(Schuster and Etnier 1978)

(3) 1983-present - The accuracy of taxonomic determinations continued to improve during this period due to the increasing experience of program personnel and the availability of many additional reference specimens. The growth in the reference collection reflected, in part, a desire to document intraspecific variations in anatomical form, such as occur among life stages or disjunct populations. Significant advances were made in the identification of members of the family Chironomidae, a large group of great diagnostic importance; these advances reflected the availability of improved taxonomic keys and the participation of program staff in identification workshops hosted by SBSK. Most remaining insect groups were identifiable to the species level during all or part of this period owing to the publication of several major works on the taxonomy of the larval life stages (Table 1.3.2-2). The distribution of most aquatic macroinvertebrate species in Kansas was also well documented through the efforts of SBSK and other researchers. This knowledge proved extremely useful in discriminating between polluted and relatively unpolluted streams.

TABLE 1.3.2-2

PRINCIPAL TAXONOMIC REFERENCES USED FROM 1983 TO PRESENT

Comprehensive Taxonomic Literature

"Freshwater Invertebrates of the United States"	(Pennak 1978,1989)
"Guide to the Freshwater Invertebrates of the Midwest"	(Huggins *et al*. 1981)
"Aquatic Insects and Oligochaetes of North and South Carolina"	(Brigham *et al*. 1982)
"Aquatic Insects of Wisconsin"	(Hilsenhoff 1982)
"Aquatic Insects of North America"	(Merrit and Cummins 1984, 1996)
"Aquatic Entomology"	(McCafferty, 1998)

Literature for Specific Taxonomic Groups

Turbellaria	(Kenk 1972)
Hirudinea	(Klemm 1982)
Oligochaeta	(Hiltunen and Klemm 1980)
Tubificidae	(Stimpson *et al*. 1982)
Bivalvia	(Murray and Leonard 1962; Burch 1973; Oesch 1984; Couch 1997)
Gastropoda	(Leonard 1959; Burch 1982)
Crustacea	(Williams and Leonard 1952; Hobbs 1972; Holsinger 1972; Capelli and Capelli 1980; Page 1985; Pflieger 1987; Pflieger 1996; Gheodoti 1998)
Isopoda	(Williams 1972)
Coleoptera	(Brown 1972; Wolfe and Matta 1981; Matta and Peterson 1985; Young 1985)
Diptera	(Boesel 1974; Beck 1976; Fredeen 1981; Soponis and Russel 1982; Ferrington 1983; Fittkau and Roback 1983; Boesel 1985; Roback 1985; Gelhaus 1986; Grodhaus 1987)
Ephemeroptera	(Burks 1953; Lewis 1974; Edmunds *et al*. 1976; Bednarik and McCafferty 1979)
Hemiptera	(Hungerford 1954; Bennett and Cook 1981)
Odonata	(Needham and Westfall 1954; Trottier 1969; Westfall and Tennessen 1979; Cannings 1981; Garrison 1981; Huggins and Harp 1985)
Plecoptera	(Stark and Gaufin 1976; Stewart and Stark 1984; Zwick 1984; Huggins 1987)
Trichoptera	(Wiggins 1977; Schuster and Etnier 1978; Hamilton and Gelhaus 1981; Schmude and Hilsenhoff 1986)

1.3.3 Development of Statistical Indicators

Prior to 1983, departmental efforts to evaluate water quality through the statistical examination of aquatic macroinvertebrate data were hampered by an inability to identify most specimens to the level of genus or species. Although Shannon-Weaver diversity, species evenness and other indices were sometimes used in an attempt to measure the impacts of water pollution on stream biological communities, taxonomic constraints generally confounded such efforts. Most biological assessments of water quality during this period were instead based on the presence or absence of insect orders and families historically associated with unpolluted aquatic habitats (e.g., Ephemeroptera, Plecoptera, Trichoptera, Elmidae). In 1984, the department began to analyze stream biological data using the macroinvertebrate biotic index or "MBI" (Davenport and Kelly 1983). This statistical measure evaluated the effects of nutrients and oxygen demanding pollutants on macroinvertebrate communities based on the relative abundance of certain indicator taxa (orders and families). Additional measures or "metrics" that were routinely utilized by this time included the Ephemeroptera-Plecoptera-Trichoptera (EPT) index and total taxa (for discussion, see Plafkin *et al*. 1989). Like the MBI, these metrics facilitated quantitative comparisons of water quality over time and between monitoring stations.

In 1985, under a contractual agreement with the Kansas Department of Health and Environment, SBSK initiated a detailed evaluation of many of the biotic indices published up to that time in an effort to identify the index best suited to aquatic macroinvertebrate communities and stream conditions in Kansas. The results of this evaluation were published three years later (Huggins and Moffett 1988) and pointed to the Chutter index (and the mathematically equivalent Hilsenhoff index) as the most desirable metric for use in Kansas (see Chutter 1972; Hilsenhoff 1977, 1982, 1987). The published report also presented preliminary pollution tolerance scores for all genera and species of aquatic insects then known to occur in the state. Individual scores, ranging from zero (least tolerant) to five (most tolerant) were proposed for six different pollution categories, including nutrients and oxygen demanding substances, agricultural pesticides, heavy metals, persistent organic compounds, salinity, and suspended solids and sediments. The SBSK report also proposed a new metric for measuring the capacity of streams to support diverse macroinvertebrate communities in the absence of water pollution problems. Designated the habitat development index or "HDI", this new metric provided a potential means of accounting for the possible effects of habitat differences on biotic index values and on other metrics.

Metrics routinely employed for diagnostic purposes at the present time include the MBI, KBI (nutrients and oxygen demanding pollutants), EPT index, EPT expressed as a percentage of total taxa, EPT expressed as a percentage of total abundance, total taxa, and HDI. Routine use of the Chutter index and the pollution tolerance scores, other than those for nutrients and oxygen demanding pollutants, developed by SBSK has been deferred pending additional field testing and validation.

1.4 Contemporary Program Objectives

The stream biological monitoring program endeavors to provide scientifically defensible information on the quality of flowing waters in Kansas through the analysis of aquatic macroinvertebrate communities. This information is intended for used in:

(1) complying with the water quality monitoring and reporting requirements of 40 CFR 130.4 and sections 106(e)(1), 303(d) and 305(b) of the federal Clean Water Act;

(2) evaluating waterbody compliance with the Kansas surface water quality standards (K.A.R. 28-16-28b *et seq*.);

(3) identifying point and nonpoint sources of pollution contributing most significantly to water use impairments in streams;

(4) documenting spatial and temporal trends in surface water quality resulting from changes in land use patterns, resource management practices, climatological conditions, and corresponding pollutant loadings;

(5) developing scientifically defensible environmental standards, wastewater treatment plant permits, and waterbody/watershed pollution control plans; and

(6) evaluating the efficacy of pollution control efforts and waterbody remediation/restoration initiatives implemented by the department and other agencies and organizations.

Section 2

QUALITY ASSURANCE GOALS

The foremost goal of this QA management plan is to ensure that the Kansas stream biological monitoring program produces data of known and acceptable quality. "Known quality" means that data precision, accuracy, completeness, comparability and representativeness are documented to the fullest practicable extent. "Acceptable" means that the data support, in a scientifically defensible manner, the informational needs and regulatory functions of the Bureau of Environmental Field Services, the Division of Environment, and the agency. The success of the program in meeting this general goal is judged on the basis of the following quality control (QC) performance criteria and requirements:

(1) Where practicable, the reliability of the program data shall be documented in a quantitative fashion. For routine metrics, such as species richness, the MBI or the EPT index and variants, the precision of the data shall be evaluated via replicate sampling activities conducted by field staff. Values for such metrics are expected to vary, on average, less than twenty percent among program personnel. Accuracy, as the term is used in this QA management plan, refers to the correct identification of biological specimens to the lowest possible taxonomic level. Accuracy is evaluated through the use of reference specimens and through internal and external audits of taxonomic performance (see section 4.6.3). As a general goal, fewer than one percent of the specimens collected in the course of sampling activities shall be misidentified by program personnel.

(2) Loss of biological data due to specimen collection, transport or storage problems, or to the subsequent mishandling of data, shall be limited to less than two percent of the data originally scheduled for generation. Where problems occur and a substantial quantity of data is lost, an effort shall be made to resample the stream or streams in question to maximize data completeness.

(3) Changes in the methods used to obtain and analyze biological samples shall be carefully documented through formal revisions to the SOPs appended to this QA management plan. This requirement is intended to help maintain a reasonably consistent database over time, enhance knowledge of the effects of any procedural changes on reported metric values, and facilitate the identification and evaluation of long-term trends in surface water quality.

(4) Data generated through this program shall be compared and contrasted with other available monitoring information to examine the representativeness of program findings relative to other reported results. Staff shall attempt to ascertain the probable causes of any discrepancies observed between the various existing databases

and describe, in end-of-year program reports, the magnitude and practical significance of such discrepancies.

Section 3

QUALITY ASSURANCE ORGANIZATION

3.1 Administrative Organization

The stream biological monitoring program is one of several environmental monitoring programs administered by the Technical Services Section, Bureau of Environmental Field Services (see BEFS QA Management Plan, QMP, Part II). Program offices are located at Forbes Field in Topeka, Kansas.

3.2 Staff Responsibilities

Program staff include two environmental scientists. The environmental scientist III serves as the program manager and is accountable for most program planning, data interpretation, and report writing functions. This employee also participates in field work, monitors program QC, appraises the section chief of any equipment or staff training needs, and participates in the annual review and revision of the program QA management plan (see section 5). The environmental scientist II routinely schedules and participates in field activities, serves as the program's principal taxonomist, and maintains the biological reference collection and taxonomic library.

Personnel from other BEFS programs occasionally assist with stream biological sampling activities, especially in the event of staff absences or when additional people are needed to conduct the work in a timely, safe and efficient fashion. Staff of the stream biological monitoring program provide reciprocal assistance to other BEFS programs.

3.3 Staff Qualifications and Training

Minimum technical qualifications for program staff vary by position. The program manager must hold at least a four-year college degree in aquatic invertebrate biology or a closely related scientific field and have substantial experience in the performance of water quality studies and associated data analysis and statistical procedures. The program manager must also understand the basic principles of supervision, program administration and quality control and possess advanced computer skills and written and oral communication skills. Also, pursuant to Part I of the divisional quality management plan (QMP), the program manager must complete formal supervisory training offered by the Kansas Department of Administration and quality assurance training offered by EPA. The program's environmental scientist II must possess a strong taxonomic familiarity with the invertebrate organisms occurring in Kansas streams. He/she must also command a thorough understanding of the procedures used in the sampling, preservation, identification, enumeration, labeling and archival of invertebrate specimens and in the processing of associated paperwork and other documentation.

All individuals routinely participating in this program must possess a valid Kansas driver's license and current certifications in first aid and cardiopulmonary resuscitation (CPR). They must review the program's QA management plan and SOPs prior to assuming field/laboratory duties and repeat this review at least annually (QMP, Part I). All program staff receive in-house training in applicable work procedures and related safety requirements. As funding and other agency resources allow, the program manager and the environmental scientist II are encouraged to participate in technical workshops and seminars dealing with environmental monitoring operations and related field, analytical, data management and statistical procedures.

Section 4

QUALITY ASSURANCE PROCEDURES

4.1 Monitoring Site Selection

The monitoring network is designed around the objectives set forth in section 1.4 of this document. Specifically, an effort is made to evaluate macroinvertebrate communities and water quality conditions in each of the state's major river basins and ecoregions (objectives 1, 2 and 4) while providing data on individual waterbodies needed to identify major sources of contaminants (objective 3), develop scientifically defensible permits and/or pollution control plans (objective 5), and assess the effectiveness of implemented pollution control or remediation efforts (objective 6). In selecting individual stations for inclusion (or retention) in the monitoring network, the following questions are posed:

(1) Would the candidate station materially enhance the spatial coverage of the monitoring network? That is, would the location coincide with an ecoregion or a major river basin currently under represented in the network?

(2) Would the candidate station reflect habitat and water quality conditions occurring throughout most of the watershed or stream segment, or would local phenomena (e.g., stream obstructions, sand and gravel removal operations, channelization projects, point sources, area cropping practices, livestock access, riparian deforestation) create conditions unrepresentative of the watershed or stream segment as a whole?

(3) Would the candidate station afford long-term access to the stream for monitoring purposes? Could access be curtailed at the discretion of a private landowner?

(4) Do historical macroinvertebrate data or water quality data exist for the candidate site? If so, does the historical database provide a reliable indication of historical water quality conditions?

(5) Do other, ancillary data exist for the candidate site? Does the site coincide with any other water quality or hydrological data collection efforts (e.g., departmental stream chemistry monitoring station; United States Geological Survey (USGS) stream flow gaging station)?

(6) Would the candidate station provide water quality data of unique interest? For example, does the site represent an unusually pristine location, suitable for use as a long-term ecoregional reference location? Does the waterbody constitute an outstanding national resource water, exceptional state water or a critical habitat for

any state or federally listed threatened or endangered species? Is the candidate site located on an interstate stream in the vicinity of the state boundary, thereby constituting a potential interstate stream monitoring station?

As mentioned previously, the current monitoring network includes several reference sites which have been sampled more frequently than other network sites. Reference sites serve to identify the variation in community structure and species abundance associated with relatively unperturbed streams in a given land use setting, geological or geographical area, or ecoregion (Gallant *et al.* 1989). Biological data obtained from reference sites may be compared to data from other sampling locations of similar habitat and hydrology, thus improving the likelihood of identifying streams with aberrant macroinvertebrate community characteristics and associated water quality problems. Reference sites will likely increase in number and play an increasingly important role in surface water quality assessments performed by the department.

4.2 Determination of Site Location

The location of each stream biological monitoring site is routinely determined with the aid of one or more USGS 7.5' topographical maps. Beginning in 2001, the longitude and latitude of all sites will be determined in the field using hand held global positioning system (GPS) equipment, if the coordinates have not been determined previously using GPS technology (Appendix 3). Coordinates are determined near the center line of the stream within the sampled reach. The use of GPS technology facilitates the interpretation of biological data in a geographical context and expedites the development of species distribution maps and similar work products (sections 1.4 and 4.12). Digital photographs also will be taken of all monitoring locations, and periodically updated, to track changes in the physical character of sites over time and to assist monitoring personnel in site identification and verification.

4.3 Sample Collection

Appendix B provides a detailed description of the sampling protocols used in this program. In the collection of quantitative macroinvertebrate samples, a time-based "equal effort" method is employed which is essentially equivalent to EPA's Rapid Bioassessment Protocol III (see Plafkin *et al.* 1989). During each sampling event, macroinvertebrate specimens are collected by two individuals using D-frame nets and forceps. Sampling activities continue for thirty minutes or a combined duration of one person- hour. An effort is made to sample all macrohabitats (riffles, pools, runs) and microhabitats present at the stream station within the allotted time period. Specific methods of collection include, but are not necessarily limited to:

(1) kicking riffles and leaf packets and allowing the current to carry dislodged organisms into the D-frame nets;

(2) sweeping the D-frame nets through submersed or floating aquatic vegetation, submersed terrestrial vegetation and tree roots, accumulations of woody debris, and growths of filamentous algae;

(3) sieving fine sediments (silt and fine sand) through the D-frame nets; and

(4) using forceps to pick organisms directly from logs, large rocks, or other surfaces not easily dislodged by kicking.

Field staff endeavor to collect a combined total of at least 200 organisms. The minimum acceptable sample size is a total count of 100 organisms. Where multiple habitats are present, no more 50 organisms are collected from a single microhabitat. Specimens of a given taxon are collected in numbers roughly proportional to their relative abundance in the stream community. Specimens are placed in 120-ml glass jars containing 70 to 80 percent ethyl alcohol. The station number and date of collection are written with indelible marker on label tape affixed to the outside of the jars. Upon completion of sampling, a field collection form is filled out by one of the workers (Appendix C). Information recorded on the form includes station number and location, time and date of sample collection, names of field workers, and flow conditions at the time of sampling. Prior to leaving the monitoring station, stream temperature is measured, a Winkler dissolved oxygen sample is collected, and an HDI form is completed (appendices B and C).

4.4 Sample Chain-of-Custody

All samples and associated paperwork are transferred to the BEFS central office in Topeka. In the unlikely event a sample is delivered by someone other than the staff involved in its collection, the courier's name and the date and time of sample transfer are recorded on the field collection form. Samples and paperwork are retained in the possession of, or delivered to, the program's environmental scientist II. This employee stores the biological samples in a secured location pending taxonomic determinations, files the field collection forms and HDI forms for future reference, and performs the necessary titration on the dissolved oxygen samples (Appendix B).

4.5 Taxonomic Determinations

Appendix B provides a detailed description of the taxonomic procedures used in this program. Macroinvertebrate samples are identified to the lowest practicable taxon utilizing literature specific to the Kansas fauna or the most appropriate, up-to-date taxonomic literature available. Voucher specimens of newly discovered or rarely encountered taxa are added to the reference collection on an ongoing basis. Opinions of outside taxonomic experts are solicited as needed. Samples are retained for a minimum of five years following specimen identification. Historical data may be adjusted to accommodate ongoing changes in the scientific nomenclature through revision of the SBSK reference file (see section 4.9).

4.6 Internal Procedures for Assessing Data Precision, Accuracy, Representativeness and Comparability

4.6.1 In-house Audits

The section chief conducts annual audits of field, analytical and taxonomic procedures. Each audit is comprised of a system audit, consisting of a qualitative, onsite review of QA systems and physical apparatus and facilities for monitoring, measurement and specimen identification, and a performance audit, in which a quantitative assessment is made of the efficiency and reliability of invertebrate sample collection and taxonomic procedures. During system audits, staff responsible for field operations are required to demonstrate a proper understanding of the requirements imposed by the QA management plan and accompanying SOPs. During performance audits, staff are required to conduct field and laboratory measurements and taxonomic determinations in the presence of the section chief, report measured values for stream temperature and dissolved oxygen concentration that fall within five percent of those established by the section chief, and report measured values for HDI and selected community metrics that fall within twenty percent of those established by the section chief (in possible consultation with other qualified staff or outside experts). Should these values fall outside the stipulated control limits, the section chief and program personnel initiate corrective actions as described in section 4.8.

4.6.2 Replicate Samples

The protocol for macroinvertebrate sample collection involves two field staff working simultaneously within the same general stream reach (section 4.2; Appendix B). The subsample obtained by one of the workers is pooled with that of the other to form a single sample. Duplicate (or replicate) pooled samples are collected consecutively and comprise approximately ten percent of the total number of samples collected on an annual basis. Overall precision (i.e., combined sample collection and taxonomic precision) is estimated for various metrics based on data obtained from these duplicate (replicate) samples. Field staff must take great care not to resample any substrate that has been physically disturbed by prior sampling or impacted by drift (movement of dislodged organisms) from upstream invertebrate sampling activities. In the event precision levels indicated by the consecutive sample method fail to meet the QC requirements of section 2, paragraph (1), the program manager and section chief invoke the corrective action measures described in section 4.8.2.

4.6.3 Taxonomic Accuracy

Taxonomic determinations are validated by comparing the list of taxa from a particular sample to the historical list of taxa for the station or stream of interest. Determinations also may be checked against the SBSK inventory of aquatic macroinvertebrates known to occur in Kansas. Rare or unusual specimens are compared to specimens in the agency reference collection (section 4.5) and, if necessary, submitted to experts at SBSK for further examination. Each year, at a rate of approximately two percent of the annual taxonomic work load, the program manager randomly selects invertebrate samples of moderate to high diversity for reidentification and reenumeration of specimens. The results of this exercise are compared with information recorded on the original identification bench sheet. Exact reproducibility is not expected as some specimens have already been subjected to dissection and removal of key anatomical features. Annual program audits conducted by the section chief evaluate, among other things, the taxonomic proficiency of program staff. If the accuracy of specimen identification fails to meet the requirements of section 2, paragraph (1), corrective action measures are initiated (section 4.8.2).

4.6.4 Preventative Maintenance

Periodic inspection and routine maintenance of field and laboratory equipment is necessary to minimize malfunctions which could result in the loss of data or disruption of project activities. Sampling equipment, such as D-frame nets and hip and chest waders, and microscopes and illuminators used in specimen identification, must be inspected periodically and repaired or replaced if necessary. Vehicles used during field activities also must be maintained in a reliable condition. Entries must be made in the vehicle log upon completion of each field trip. All vehicle malfunctions must be reported to the central motor pool as soon as possible to expedite necessary repairs or the acquisition of a replacement vehicle.

4.6.5 Safety Considerations

Attention to job safety protects the health and well-being of program staff and helps maintain a work atmosphere which ultimately enhances data quality and consistency. Program staff must be familiar with proper precautionary measures and the use of available safety equipment prior to assuming field duties. All field staff must be certified in adult cardiopulmonary resuscitation and basic first aid by the American Red Cross or an equivalent institution. All vehicles routinely used in the stream biological monitoring program must be maintained in proper condition and equipped with first aid kits, emergency eye wash bottles, fire extinguishers, spare tires and tire changing equipment, rain gear, road reflectors and/or flares, and operable flashlights. Before leaving for the field, monitoring personnel are expected to check out a cellular phone from BEFS clerical staff to use in the event of a vehicle mishap, medical problem, or other emergency. Access to a cellular phone is particularly important when traveling alone, conducting overnight sampling runs, or traveling during periods of potentially severe weather. Additional safety considerations are presented in the SOPs accompanying this QA management plan.

4.7 External Procedures for Assessing Data Precision, Accuracy, Representativeness and Comparability

At the discretion of the section chief, bureau QA representative, bureau director, or divisional QA officer, the stream biological monitoring program may, from time to time, participate in independent performance/system audits or in interagency exchanges or comparisons of macroinvertebrate reference samples. Participation in such activities promotes scientific peer review and enhances the technical integrity and overall credibility of the program.

4.8 Corrective Action Procedures for Out-of-Control Situations

4.8.1 Equipment Malfunction

Any equipment malfunction discovered during routine sampling or taxonomic activities, or during an internal or external performance audit, must be reported immediately to the program manager. This employee is responsible for appraising the scope and seriousness of the problem and, if necessary, for determining whether the equipment item should be repaired or replaced. The program manager also is responsible for ensuring that backup equipment is available for all critical field and taxonomic activities. Arrangements for a backup vehicle must be made in advance of any mechanical problems or mishaps that might render the program's regular vehicle inoperable for an extended period.

4.8.2 Data Precision/Accuracy Problems

If sampling activities or taxonomic determinations fail to meet the requirements of section 2, paragraph (1), the program manager must plan and implement an investigation to determine the cause of the problem. The program manager is expected to work closely with staff in this endeavor and in the selection and implementation of appropriate corrective measures. Persistent problems may trigger a program audit by the section chief, result in the disqualification of a substantial amount of stream biological data, or invoke other remedial responses (e.g., an independent audit).

4.8.3 Staff Performance Problems

If an employee has difficulty with a given work procedure, as determined by an internal or independent performance audit, an effort must be made by the program manager to identify the scope and seriousness of the problem, to identify any data affected by the problem, and to recommend to the section chief an appropriate course of corrective action. All questionable data are either flagged within the computer database or, at the discretion of the section chief, deleted from the database. Possible corrective actions include further In-house or external training for the employee, a reassignment of work duties, or modification of the work procedure.

4.9 Data Management

4.9.1 General Data Management

All field- and laboratory-generated data are handled in an orderly and consistent manner. Time and date of sample collection, stream monitoring station identification number, and other basic field information, including habitat evaluations, are recorded on standardized field forms; similarly, taxonomic determinations and metric scores are recorded on standardized biological data forms (Appendix C). The original forms are carefully reviewed for obvious errors or omissions and are subsequently filed in a secured location for future reference.

Information on biological data forms is transferred manually to the Kansas Biological System database maintained on an IBM AS-400 minicomputer supported by the agency's Office of Information Systems (OIS). This relational database (QUERY) also contains station identification headers; sample collection date/time files; SBSK codes for individual macroinvertebrate species and other taxonomic designations; pollution tolerance values and other rating systems for calculation of biotic indices; and other supporting information. Custom program screens have been designed by OIS to facilitate database access and the viewing, validation and editing of program data. The program database is backed-up by OIS on a daily basis.

Transfers of raw data may be accomplished by downloading selected portions of the database to ASCI or other file formats. Several customized reporting formats have been designed by OIS. These allow the raw data to be sorted or restricted based on station number, date of sample collection, or SBSK code, with or without associated station header information, metric values, and other supporting information. Retrievals may be printed, viewed, or downloaded as ASCI or .dbf files. Calculated values for various biological metrics also are maintained on a personal computer spreadsheet (currently Quattro Pro, version 8). These values are downloaded directly from the AS-400. Calculated values may be retrieved and reported in various formats or subjected to basic statistical analyses. The computer spreadsheet is stored on a computer hard disk that is backed up on a CDROM every two months.

4.8.2 Data Entry Requirements

All environmental data (and metadata) manually entered in the program's electronic database are examined by visually comparing database retrievals with the original bench identification sheets (Appendix C). The database is subsequently corrected for any data entry errors. Staff transferring or receiving data electronically also perform random spot checks of the data and report any problems to OIS for further investigation and resolution. Persistent problems are reported to the section chief and bureau QA representative for consideration of necessary corrective actions.

4.8.3 Verification of Calculations

Computer-based mathematical, statistical, graphical and geographical programs and models involving environmental data are tested before application by comparison to other computer programs, through hand calculations involving randomly selected data, or through other appropriate means. The reliability of these models and programs is reexamined on at least an annual basis or whenever a problem is reported within a computational system. Quattro Pro, Excel, ArcView and PC SAS are among the forms of software used for generating spreadsheets, graphs and models or for performing statistical characterizations, comparisons and trend analyses.

4.8.4 Data Transformation and Outliers

Many forms of environmental data do not conform to a normal distribution and may necessitate the use of nonparametric statistical methods. Alternatively, the data may be transformed statistically to induce a normal, log normal, or some other preferred data distribution. The data distribution is often depicted graphically to help identify the most appropriate transformation procedure. Commercially available computer programs also may be applied in more detailed assessments of data distribution. PC SAS software maintained on one of the BEFS desk top computer offers several algorithms for characterizing departure from normality (e.g., Shapiro-Wilk and Kolomogorov tests available through the UNIVARIATE procedure).

All environmental databases may contain a few anomalous values or statistical outliers. Obvious outliers (those that are orders of magnitude beyond any reasonable value) often constitute data transcription errors or other simple errors. In the stream biological monitoring program, data are automatically questioned by staff if a calculated metric is outside the historical range for the waterbody in question. Such an occurrence may prompt another comparison of the information stored on the program database with the information recorded on the bench identification sheet. The program manager also may elect to reexamine the computer algorithms used to generate the metric. If necessary, the original sample may be retrieved from storage and reexamined by the environmental scientist II. In other instances, outliers may reflect actual (though rarely occurring) fluctuations in water quality. Nonparametric procedures based on rank-order or percentile tend to be less influenced by these kinds of data and are often favored by staff for statistical characterizations, comparisons and trend analyses.

4.8.5 Ancillary Data

Ancillary data used in this program may include physicochemical, hydrological, meteorological or biological data derived from other BEFS programs or other governmental agencies. All routine environmental monitoring programs administered by BEFS are subject to the provisions of parts I and II of the divisional QMP. An effort is made to ensure that data from outside agencies are generated in accordance with QA management plans similar to those developed by BEFS. In some instances, outside agencies collect data under a contractual agreement with the division, or under the auspices of an EPA grant, both of which require development and approval of a QA project plan prior to data collection (see QMP, Part I, section 2.3).

Biological metrics and species tolerance values applied in the program are taken largely from documents produced by other governmental agencies or from literature sources incorporating peer review of articles before publication. Staff carefully examine the underlying technical assumptions before applying these metrics and values in the stream biological monitoring program.

4.10 Quality Assurance Reporting Procedures

End-of-year program evaluations shall be conducted by the section chief and a written report submitted to the office director and deputy division director by February 15 of the following year. The program manager shall cooperate fully in the evaluation of QA/QC performance and shall make available all records pertaining to the precision, accuracy, representativeness and comparability of the monitoring data gathered during the evaluation period. Program evaluations submitted by the section chief must indicate when, how, and by whom the evaluation was conducted, the specific aspects of the program subjected to review, a summary of significant findings, and technical recommendations for necessary corrective actions. The section chief shall discuss the reported findings with the program manager and other program staff.

4.11 Purchased Equipment and Supplies

When newly ordered or repaired sampling, diagnostic or computational equipment is delivered to the program office, program personnel compare the item to that requested on the original order, then inspect the item to ensure no breakage has occurred in transit and all components function properly. The shipment is either accepted or rejected once this inspection is completed.

Office and laboratory supplies receive a comparable level of scrutiny. Any reference standards or reference apparatus must be accompanied by a certificate from the vendor or manufacturer verifying the quality of these products.

4.11 Program Deliverables

Program deliverables include electronic databases, illustrative materials, statistical water quality summaries, and detailed written reports used in a variety of agency applications. Staff of the stream biological monitoring program play a major role in the development of the Kansas biennial water quality assessment (305(b)report) and the Kansas list of water quality limited surface waters (303(d) list). As resources and circumstances allow, customized data retrievals are prepared by the program manager on behalf of administrative staff, legislative officials, other state and federal agencies, regulated entities, special interest groups, consultants, academicians, students, and members of the general public.

Section 5

REVIEW AND REVISION OF PLAN

To ensure that the stream biological monitoring program continues to meet the evolving informational needs of the bureau and the agency, all portions of this QA management plan and its appended SOPs must be comprehensively reviewed by participating staff on at least an annual basis. Revisions to the plan and SOPs require the approval of the program manager, section chief and bureau QA representative prior to implementation. Although review activities normally follow the annual program evaluation in February, revisions to the plan and SOPs may be implemented at any time based on urgency of need or staff workload considerations.

Original approved versions of the QA management plan and SOPs, and all historical versions of these documents, are maintained by the bureau QA representative or his/her designee. The bureau QA representative also maintains an updated electronic version of the plan and SOPs on the KDHE internet server in a "read only" .pdf format.

APPENDIX A

FIELD AND LABORATORY EQUIPMENT

AND SUPPLY CHECKLIST

FIELD AND LABORATORY EQUIPMENT AND SUPPLY CHECKLIST

I. VEHICLE

A. Three-quarter ton van (or other vehicle, as available)

B. Vehicle registration and proof of insurance

C. Vehicle log book (credit card, Fuelman card, list of Fuelman service stations, copy of tire and battery service contracts,

D. State highway and 1/4" scale county maps

E. Vehicle key and spare key(s)

F. Mobile cellular phone (with magnetic mountable antenna, carrying case, and instruction booklet, as appropriate)

G. Fire extinguisher, first aid kit, CPR mouthpieces, latex rubber gloves, paper and cloth towels, hand sanitizing solution in plastic squeeze bottle, safety goggles, portable eye wash station

H. Spare tire (fully inflated), tire changing equipment, road reflectors and/or flares

I. Tool kit, jumper cables, tow rope, windshield ice scrapers, flashlights (fully operable), fluorescent orange safety vests with reflective strips

II. FIELD EQUIPMENT AND SUPPLIES

A. Garmin GPIII+ hand-held GPS unit (with Garmin *MapSource* software)

B. Camera, 35-mm, with film, digital diskettes or cards, carrying case, instructions

C. Hip or chest waders (two pair in use; one spare pair) and tube of silicon sealant for emergency repairs

D. D-frame, 0.5-mm mesh nylon nets (two in use; one spare) with 1.5-meter wooden handles calibrated in decimeters for measuring stream depth

E. Forceps (fine point, on lanyard)

F. Glass sample jars (120 ml) with screw-on plastic lids

G. Label tape (white) for sample jars

H. Ethanol solution (70-80%) for preserving invertebrate specimens

I. Stop watches for timing sampling events

J. Field collection forms

K. Habitat development index forms

L. Metal clipboard (with maps, field forms, etc.), pens, pencils, and indelible markers

M. Fisher model #15-0778 stainless-steel dial scale thermometer (-10 to +110^{o}C)

N. Standard glass bottles (250 ml) with glass stoppers used for dissolved oxygen samples

O. Winkler dissolved oxygen kit (with reagents "1, 2, 3" in 250-ml Nalgene safety bottles, transported in sealed plastic container with removable lid; see Appendix B)

P. Plastic three-gallon bucket with padded steel handle for transporting samples and smaller equipment/supply items from stream monitoring location to van, etc.

Q. Rain gear, caps or visors, sunglasses, sun screen, insect repellant, hand disinfectant solution, drinking water, extra socks in the event of wader leakage

III. TAXONOMIC EQUIPMENT AND SUPPLIES

A. Bausch and Lomb 40X-400X variable magnification compound microscope

B. Bausch and Lomb 10X-70X variable zoom dissecting microscope

C. Dyonics dual fibre optics, variable intensity light source

D. Glass Petri dishes

E. Steel forceps and probes (coarse and fine point)

F. Microscope slides and slide cover slips

G. Euparal mounting medium

H. Lab-Line hot plate

I. Identification bench sheets (Appendix C)

J. Ethanol (70-80% with 5% glycerine) for preserving invertebrate specimens

K. Taxonomic keys and supporting scientific literature

L. Boxes for storage of invertebrate samples (in original glass sample jars) following identification and enumeration of specimens

N. Specimen vials and trays for reference collection

M. Locking cabinet for reference specimen collection

APPENDIX B

STANDARD OPERATING PROCEDURES

TABLE OF CONTENTS

Procedure	Revision No.	Date
Maintenance Procedures for Field Sampling Equipment (SBMP-001)	0	12/01/00
Procedures for Field and Laboratory Analytical Measurement (SBMP-002)	0	12/01/00
Procedures for Collection of Macroinvertebrate Samples (SBMP-003a)	0	12/01/00
Procedures for Qualitative Observation and Documentation of Unionid Mussel Communities (SBMP-003b)	0	12/01/00
Procedures for Preparation, Identification, Enumeration and Preservation of Biological Specimens (SBMP-004)	0	12/01/00
Procedures for Completion of Habitat Development Index Form (SBMP-005)	0	12/01/00
Vehicle Safety and Maintenance Procedures (SCMP-002)	0	12/01/00
Procedures for Determining Geographical Coordinates of Stream Biological Monitoring Sites (BWM-007)	0	12/01/00

MAINTENANCE PROCEDURES FOR FIELD SAMPLING EQUIPMENT (SBMP-001)

I. INTRODUCTION

A. Purpose

Sampling equipment must be maintained in a reliable working condition to maximize the efficiency of invertebrate collection activities and minimize the loss of data.

B. Minimum Staff Qualifications

These procedures normally are performed by program field personnel but may be performed by virtually any other employee after limited initial training.

C. Equipment/Accessories

1. Hip and chest waders

2. D-frame aquatic nets

II. PROCEDURES

A. Hip and chest waders

1. When waders are not in use, they should be stored in an inverted position in a cool, dark location to reduce cracking.

2. Rips and tears are repaired with silicone seal or adhesive patches, depending on the extent of damage and wader construction.

3. Mud is removed prior to storage.

4. Insides of waders must be kept dry to reduce deterioration of lining material.

B. D-frame aquatic nets

1. Nets are checked for damage after each sampling event.

2. Rips and tears are repaired with silicone seal or sewn closed.

3. Depth graduations on the handles eventually fade and must be retraced from time to time with indelible marker.

PROCEDURES FOR FIELD AND LABORATORY ANALYTICAL MEASUREMENTS (SBMP-002)

I. INTRODUCTION

A. Purpose

The following paragraphs describe the procedures used by program staff to measure stream temperature and dissolved oxygen concentrations.

B. Minimum Staff Qualifications

Personnel implementing this SOP should meet the minimum classification requirements for environmental technician II published by the Kansas Department of Administration. They also should be experienced in the measurement of the chemical and physical properties of surface water and have a basic technical understanding of the associated measurement apparatus.

C. Equipment and Accessories

1. Fisher model #15-0778 stainless-steel dial scale thermometer

2. Standard 250-ml glass bottles with glass stoppers for dissolved oxygen samples, Winkler dissolved oxygen kit (with reagents "1, 2, 3" in 250-ml Nalgene safety bottles, transported in sealed plastic container with removable lid), and, for laboratory use, a 25-ml burette (filled with titration reagent), 250-ml graduated cylinder and 500-ml Erlenmeyer flask

II. PROCEDURES

A. Stream Temperature Measurement

Immerse lower half of thermometer probe into flowing reach of stream, preferably above “thalweg” or line connecting deepest points along stream channel. On sunny days, take temperature reading in shaded reach of stream or in own shadow. After indicator on thermometer dial has stabilized, read temperature to nearest full degree Celsius.

B. Collection and Titration of Stream Dissolved Oxygen Sample

1. Collect dissolved oxygen (DO) sample from flowing reach of stream, preferably from thalweg. Remove stopper from dissolved oxygen bottle and hold portion of lip of bottle slightly below surface of stream. Allow bottle to

fill with water slowly and with minimal aeration. After filling, hold bottle in upright position below surface of water, tap bottle to release any trapped air bubbles, and reinsert stopper before removing bottle from water. Carefully inspect bottle for air bubbles. Repeat above sampling procedure if any air bubbles are observed. After sample without air bubbles is obtained, immediately return sample to van for preservation.

2. Upon returning to van, don disposable polyethylene gloves and safety goggles or other appropriate hand and eye protection.

3. Add 2 ml of manganous sulfate to sample from Winkler DO kit. This reagent is contained in squeeze bottle labeled #1. When using squeeze bottle, force reagent into 2-ml dispensing pipette tip by gently squeezing bottle. Dispense reagent by inverting squeeze bottle while placing pipette tip just above surface of sample.

4. Add 2 ml of alkaline potassium iodide azide. The squeeze bottle containing this reagent is labeled #2.

5. After reagents #1 and #2 have been added to DO bottle, close stopper and invert bottle 25 times for thorough mixing of reagents and sample. Set sample aside until floc has settled one-third of way down bottle. Floc will settle more rapidly in warmer samples than in colder samples.

6. After floc has settled one-third of way down bottle, carefully add 2 milliliters of concentrated sulfuric acid from squeeze bottle labeled #3.

7. Replace stopper, rinse outside of bottle with deionized water or stream water, and invert bottle 25 times to break up floc and ensure thorough mixing of sample and reagents. (Development of a dark brown color generally indicates a high amount of DO in sample, whereas a light amber or clear color indicates little or no DO.) Secure sample in deeply shaded area of van pending transfer to BEFS laboratory in Topeka.

8. Upon arrival at BEFS laboratory, fill 25-ml burette with 0.025 M sodium thiosulfate solution (bottom of meniscus should correspond to zero reading at top of burette cylinder). Maintain aluminum foil wrapping on burette to prevent degradation of sodium thiosulfate solution by ambient light.

9. Decant 200 ml of sample into dedicated 250-ml graduated cylinder. Transfer this volume to 500-ml Erlenmeyer flask.

10. Twirl flask to mix contents while titrant is dispensed slowly from burette. Continue titration until contents of flask turn a pale, straw yellow.

11. Add 2.0 ml of starch solution to flask, turning contents blue. While gently swirling flask, add titrant slowly until solution finally loses all blue color. This end-point is best judged by holding flask against a white sheet of paper or white wall.

12. Read DO concentration in sample directly from burette. Milliliters of sodium thiosulfate solution required to invoke color change equal DO concentration in mg/L. Rinse flask and cylinder with distilled water between samples. Do not use chlorinated tap water, which may interfere with Winkler titration.

PROCEDURES FOR COLLECTION OF MACROINVERTEBRATE SAMPLES (SBMP-003a)

I. INTRODUCTION

A. Purpose

Staff involved in the collection of macroinvertebrate samples must adhere to a standardized sampling procedure to maximize the comparability of the data generated by different workers over a potentially long period of time. Consistent procedures reduce the statistical "noise" that could otherwise detract from the utility of the data.

B. Minimum Staff Qualifications

Staff implementing this position must meet the minimum classification requirements for environmental scientist II published by the Kansas Department of Administration. They also must possess a strong familiarity with the range of macroinvertebrate organisms occurring in Kansas streams and command a thorough understanding of the procedures used in obtaining representative macroinvertebrate samples.

C. Field Equipment and Supplies

For complete list of equipment and supplies, see Appendix A.I-A.II. Primary sampling gear is listed below:

1. Hip or chest type waders depending on the depth and flow conditions of the stream being sampled

2. D-frame, 0.5-mm mesh aquatic net with decimeter graduations on handle for depth determination

3. Forceps (fine point with lanyard)

4. Glass sample jars (120 ml) containing 70-80% ethanol (approximately 50 ml per jar); white tape for labeling jars; indelible markers

5. Stopwatch (or wrist watch with stopwatch function)

6. Field Collection Data Sheet (Form App.C-1); pencils; indelible pens

II. PROCEDURES

A. During each sampling event, macroinvertebrate specimens are collected by two workers over a period of thirty consecutive minutes (a combined duration of one person-hour).

B. All available macrohabitats (riffles, pools, runs) and microhabitats are sampled, as permitted by size of water body and time allotted (see SOP No. SBMP-005).

C. Macroinvertebrate specimens are collected by:

1. kicking riffles and leaf packets and allowing current to carry dislodged organisms (and debris on which organisms may occur) into D-frame nets for removal with forceps;

2. sweeping the D-frame nets through submerged or floating aquatic vegetation, submersed terrestrial vegetation and tree roots, accumulations of woody debris, and growths of filamentous algae;

3. sieving fine sediments (silt and fine sand) through the D-frame nets; and

4. using forceps to directly pick organisms from logs, large rocks, or other surfaces not easily dislodged by kicking.

D. Each worker endeavors to collect at least 100 organisms, for a total of 200 or more organisms per pooled sample.

E. Different macroinvertebrate taxa present at a site are collected in numbers roughly proportional to their relative abundance in the stream community. Neither worker should collect more than 50 organisms from any single microhabitat.

F. As specimens are separated from debris, they are placed directly into glass sample jars containing 70-80% ethanol. Using an indelible marker and white label marking tape, jars are identified with regard to station number and collection date.

G. Upon completion of the sampling effort, a field collection form is filled out by one of the workers (Appendix C). Information recorded on the form includes station number and location, time and date of sample collection, names of sample collectors, and flow conditions at the time of sampling.

III. SAFETY

A. Standard operating procedure SCMP-002, addressing vehicle safety and maintenance, is adopted by reference.

B. Field crews in the stream biological monitoring program shall consist of two or more individuals. Crew members shall remain within hearing distance of one another during sampling activities, in the event of an accident or some other situation requiring prompt assistance. Crew members shall be certified in adult cardiopulmonary resuscitation and basic first aid by the American Red Cross or equivalent institution. Any lapse in certification shall render an employee ineligible for macroinvertebrate sampling activities, pending renewal of certification.

C. If stream current velocity exceeds 10 cm/sec, crew members shall not attempt to wade through water greater than one meter in depth (or above crotch level in chest waders). Wading in stronger currents shall be limited to water less than knee deep. Workers must remain cognizant of the inherent risk of wading in stronger currents, even in relatively shallow water. Added caution is required when walking on algal-coated rocks or other slippery surfaces.

D. Workers shall not attempt to enter or remain in streams if lightening is observed or if heavy rainfall, rising water level and/or current velocity, strong wind, or any other factor precludes the collection of samples in a safe manner or in accordance with established protocols.

E. Workers shall avoid wading in excessively deep water, where even slight, unexpected increases in depth may result in overtopping of waders. Sampling in highly turbid water must be performed with caution, owing to possible sudden increases in depth, changes in substrate stability, or unexpected encounters with entangling woody debris or other submerged obstacles.

PROCEDURES FOR QUALITATIVE OBSERVATION AND DOCUMENTATION OF UNIONID MUSSEL COMMUNITIES (SBMP-003b)

I. INTRODUCTION

A. Purpose

Freshwater mussels occur in many Kansas streams but are seldom collected in quantitative macroinvertebrate samples owing to their comparatively large size as adults, burrowing habits, and sparse or scattered distribution in stream channels. Most mussel taxa are long-lived but slow to mature and reproduce. The larvae of all but a few species are parasitic on the fins and gills of fish, whereas juvenile and adult mussels live as sedentary filter-feeders. Mussel communities are unusually vulnerable to declines in environmental condition and serve a useful diagnostic function in biological assessments of water quality. The following paragraphs describe qualitative procedures employed by staff for determining the species of mussels inhabiting a particular stream reach and for ascertaining changes in the composition of mussel communities over time.

B. Minimum Staff Qualifications

Unless specifically exempted by the section chief, in writing, staff implementing this SOP must meet the minimum classification requirements for environmental scientist II published by the Kansas Department of Administration. In all cases, these staff must demonstrate an ability to accurately and rapidly identify each of the state's more than forty species of mussels under field conditions. This ability is usually gained by careful study of preserved specimens and by accumulation of field experience under the supervision of a biologist knowledgeable in mussel taxonomy.

C. Field Equipment and Supplies

1. Hip or chest waders, depending on depth and velocity of stream being sampled

2. Camera (35-mm film or digital) for documenting any rare (e.g., threatened or endangered) mussel species represented by live individuals

3. Calipers for measuring length and height of any encountered rare species

4. Five-gallon bucket with padded steel handle for transporting collected (recent, weathered, relict) shell material to field vehicle

5. Plastic bags and indelible markers for segregating and labeling shell material from different sites and transporting to BEFS laboratory in Topeka

6. Clipboard containing field forms (see below), pens and pencils

II. PROCEDURES

A. All safety procedures presented in SOP No. SCMP-002 and SBMP-003a are adopted by reference.

B. A tally of any live mussels encountered during quantitative sampling activities (SOP No. SBMP-003a) may be recorded on Form App.C-4. However, efforts to deliberately locate live mussels should await completion of quantitative sampling and other related activities. At that time, live mussels may be located by:

1. walking along stream margin, inspecting stream bottom near shoreline;

2. observing tracks left by mussels in softer sediment and manually withdrawing buried mussels from terminus of tracks;

3. inspecting bottom sediments while wading upstream in shallower, clearer reaches, allowing current to sweep away suspended material and maintain visibility;

4. wading slowly in any direction through deeper or more turbid reaches, locating mussels by feel of hand or booted foot; and

5. digging by hand into gravel- or cobble-bottom riffles, locating mussels by sense of touch.

C. Record site information and scientific names of any live mussel specimens on Live Mussel Recording Form (Form App.C-4). Maintain a running tally of species encountered and record any other useful information under remarks section of form. If threatened or endangered species or new records for sampling station are encountered, representatives of all observed age/size classes should be photographed and measured with respect to length and height. Record measurement data on Form App.C-4 to document age/size classes present at site.

D. Recent shell materials (i.e., freshly dead mussels) generally are characterized by unweathered periostracum or by periostracum weathered only in umbonal region; by unweathered nacre displaying original color and iridescence; by two valves joined by a tough but flexible proteinaceous ligament; and, in some instances, by attached soft-body tissue. Recent shell material provides important information on the composition of existing mussel communities and may be located by:

1. walking along stream margins and inspecting stream bottom near shoreline;

2. inspecting bottom sediments while wading upstream in shallower, clearer reaches, allowing current to sweep away suspended material and maintain visibility;

3. walking along sand and gravel bars during periods of low stream flow, looking for remains of mussels left by predatory animals or by stranding of live mussels following rapid reductions in flow; and

4. looking for remains of mussels within any stands of vegetation at head of sand and gravel bars and amid accumulations of driftwood and other debris, especially following periods of high flow.

E. Weathered shell material is characterized by more significant loss or peeling of periostracum; loss of nacre color and/or development of chalky nacre; brittleness of ligament; and some loss of finer structural features, especially with respect to lateral and pseudocardinal teeth. Relict shell material consists of severely weathered single valves lacking any periostracum or nacre coloration and often devoid of any finer sculptural detail. Weathered and relict shell material may be located by:

1. walking along sand and gravel bars during periods of low stream flow, withdrawing partially buried valves from deposited sediment; and

2. walking or wading along steeper, erosional shorelines, extracting buried or partially buried valves from stream bank (note: such material requires careful interpretation, in that it may range from a few years to several hundred years or more in age).

F. Collected shell material is sorted onsite to reduce redundancy and bulk. For any given species, only the most recent material is transported to BEFS laboratory; i.e., weathered and relict shell material is retained only if unweathered material is unavailable. Retained material is transported to the field vehicle in plastic buckets, then transferred to clear, heavy duty plastic bags labeled in indelible ink with the following information: name of stream, biological monitoring station number, collection date, and names of collectors. Bags are sealed with wire closures to prevent spillage and mixing of shell material from different sampling locations.

G. Shell materials transported to the BEFS laboratory are carefully cleaned with warm tap water and a soft-bristled brush, then placed on sheets of recycled computer paper near a floor fan until dry. All materials are labeled in indelible ink with a unique code (e.g., NE90023) identifying the river basin of origin, year of collection, and order of assignment to archive collection. For each assigned archive code, the following information is recorded on the Mussel Shell Archival Form (Appendix C):

stream basin, stream name, biological monitoring station number, narrative and legal site descriptions, names of collectors, collection date, scientific name of specimen, relative abundance of taxon at site (uncommon, common, abundant), shell length and height (mm), and shell condition (recent, weathered, relict). Any other information of interest is recorded on the form under comments section. If a specimen comprises two, paired valves, each is labeled with the same alphanumeric identifier. Archived specimens are returned to their original plastic bags and stored in heavy duty cardboard boxes for archival purposes.

H. Collected shell material is stored for approximately two years in a secure location at the BEFS central office in Topeka, then moved to long-term storage in a secure location at the Topeka Correctional Facility. Rare mussel specimens may be temporarily removed from storage and included in the BEFS reference collection pending procurement of additional reference specimens. At the section chief's discretion, archived specimens may be donated to museum or university reference collections following entry and verification of associated data in the Kansas mussel distribution database.

PROCEDURES FOR PREPARATION, IDENTIFICATION, ENUMERATION AND PRESERVATION OF BIOLOGICAL SPECIMENS (SBMP-004)

I. INTRODUCTION

A. Purpose

Procedures employed in the identification and enumeration of quantitative macroinvertebrate samples and preservation of voucher specimens are described in this SOP.

B. Minimum Staff Qualifications

Staff implementing this position must meet the minimum classification requirements for environmental scientist II published by the Kansas Department of Administration. They also must be well versed in aquatic invertebrate taxonomy and possess a strong familiarity with the macroinvertebrate taxa known from the streams of Kansas. The required level of knowledge normally is gained through a combination of college course work and several years of active research in this field.

B. Equipment/Accessories

1. Bausch and Lomb 10X-70X variable zoom dissecting microscope with Dyonics, dual fiber optic, variable intensity light source or equivalent light source

2. Baush and Lomb 40X-400X variable magnification compound microscope with integral light source or equivalent light source

3. Glass or plastic Petri dishes, coarse and fine point dissection probes, fine and extra fine forceps

4. Specimen vials, specimen vial trays, solution of 70-80% ethanol and 5% glycerine, reference collection housed in locking storage cabinet

5. Microscope slide storage boxes, microscope slides, microscope slide cover slips, Euparal mounting and clearing medium, glycerine, hot plate for drying and curing slide mounts

6. Taxonomic keys and supporting references

II. PROCEDURES

A. Identification and enumeration of macroinvertebrate samples in the laboratory begin with completion of the biological data form (Appendix C). Station number and location, collection date, and collectors' names are transcribed from the sample jar and field collection form. The examination date and name of examiner are likewise recorded on the biological data form.

B. Contents of the two jars that make up a sample are pooled in one or two Petri dishes. Extraneous debris is removed and the organisms are presorted with the unaided eye into various phylogenetic groups (order, family or genus).

C. After preliminary sorting, the organisms are examined individually with a dissecting microscope, further sorted and identified, and enumerated on the biological data form.

D. Certain taxonomic groups, small specimens, and certain anatomical features of some groups may need to be mounted on a microscope slide and examined under higher magnification (early instars, midge head capsules, mayfly gills, riffle beetle male genitalia, etc.). Euparal mounting medium is used to clear chitin and permanently mount midge head capsules for identification to the genus level. Euparol mounts are cured with gentle heat from a hot plate.

E. An attempt is made to identify all specimens to the lowest practicable taxonomic level, generally genus or species. Taxonomic works written specifically for the fauna of the state or region are preferentially utilized. Unusual or unprecedented determinations are compared to comprehensive lists of macroinvertebrate species known to occur in Kansas. These lists are maintained by SBSK.

F. A reference collection is maintained of all aquatic macroinvertebrate taxa encountered historically in the monitoring program. This collection is helpful when working with difficult groups or less frequently encountered species, and it provides a valuable training and educational tool. Many specimens included in the collection have been identified or confirmed by experts at SBSK.

G. After specimens have been identified and enumerated, pooled samples are transferred to storage and maintained there for a minimum of five years.

H. Microscopes must have dust covers in place at all times when not in use. Cleaning of optics is performed with lens tissue and, if necessary, cleaning solvent. The condenser on the compound microscope is periodically adjusted to maintain maximum performance and resolution.

PROCEDURES FOR COMPLETION OF HABITAT DEVELOPMENT INDEX FORM (SBMP-005)

I. INTRODUCTION

A. Purpose

This SOP provides instructions for the completion of the Habitat Development Index or "HDI" form (Form App.C-2). The form is competed in the field upon conclusion of quantitative biological (macroinvertebrate) collection activities. The resulting HDI score is a numerical expression of the capacity of a stream to support a diverse biological community in the absence of water pollution problems or other significant perturbations. A comparison of HDI scores among different sites is useful in accounting for the possible effects of habitat differences on biotic index values.

B. Equipment/Accessories

1. Measuring pole or D-frame aquatic net with handle graduated in decimeters

2. Hip or chest waders, depending on water depth and prevailing flow conditions

II. CALCULATION PROCEDURES

A. Minimum Macrohabitat Score

Each of the three types of macrohabitats (riffle, pool, run) are scored as a "3" if present in the stream and sampled; if a macrohabitat is not present or sampled, it is given a score of "0."

B. Average Depth

Average depth of each of the macrohabitats sampled is rated as a "0", "1" or "2" according to the average depth categories on the HDI form.

C. Riffle Substrate Score

This score evaluates the habitat provided by a riffle in terms of the quality and quantity of cobble present. Quality is defined as degree of embededness. Quantity is defined as the percentage of cobble in the riffle. Embededness which inhibits macroinvertebrate colonization is the only HDI parameter which may actually lower the riffle quality score and overall HDI score.

D. Organic Detritus and Debris

The types and quantity of organic debris actually sampled within each macrohabitat are collectively rated as "0", "1", "2" or "3." Examples of organic debris are indicated on the HDI form. For the purposes of this form, a "log" is considered to be any woody debris greater than 2.5 inches (24 cm) in diameter.

E. Algal Masses

Algal growths which provide some macroinvertebrate habitat are rated "0" for absence and "1" for presence in each of the macrohabitats sampled. (Periphytic growths are rated "0", as they constitute food for grazers but provide little shelter.)

F. Macrophytes

Macrophytic vegetation provides habitat and is rated "0", "1" or "2" according to absence or presence and quantity within each of the macrohabitats sampled. Examples of macrophytes that provide macroinvertebrate habitat are provided on the HDI form.

G. Bank Vegetation

Bank vegetation provides habitat and is rated "0", "1" or "2" according to absence or presence and quantity within each of the macrohabitats sampled. Examples of bank vegetation that provide suitable habitat are provided on the HDI form.

H. Final Habitat Score

Scores are totaled for each of the macrohabitats sampled, and subtotals are totaled to derive the final HDI score.

VEHICLE SAFETY AND MAINTENANCE PROCEDURES (SCMP-002)

I. INTRODUCTION

A. Purpose

This SOP outlines vehicle safety and maintenance procedures used during the collection and transport of stream biological samples. Safety procedures are established to prevent or minimize property damage, personal injuries, and/or loss of life. Maintenance procedures are established to prevent or minimize vehicle breakdowns and to extend the usable life of the vehicle.

B. Minimum Staff Qualifications

Personnel implementing this SOP should meet the minimum classification requirements for environmental technician II published by the Kansas Department of Administration. They also must possess a valid Kansas driver's license and current certifications in both standard first aid and cardiopulmonary resuscitation (CPR). Although not required, these employees are strongly encouraged to participate in defensive driving courses offered by some law enforcement agencies and other qualified organizations.

C. Equipment/Accessories

Van, three-quarter ton, or other sampling vehicle, as available

II. PROCEDURES

Procedures described in BEFS SOP No. SCMP-002 are adopted by reference.

PROCEDURES FOR DETERMINING GEOGRAPHICAL COORDINATES OF STREAM BIOLOGICAL MONITORING SITES (BWM-007)

I. INTRODUCTION

A. Purpose

Accurate documentation of geographical position (longitude and latitude) reduces the risk of obtaining environmental samples from the wrong monitoring site and facilitates the analysis of monitoring data through geographical information system (GIS) techniques. Beginning in 2001, the location of all stream sites visited by staff for biological sampling purposes must be precisely documented using GPS procedures.

B. Minimum Staff Qualifications

Personnel implementing this SOP should meet the minimum classification requirements for environmental technician II published by the Kansas Department of Administration. They also should be experienced in the use of GPS equipment and possess a basic understanding of the underlying technology.

C. Equipment/Accessories

1. Garmin GPSIII+ hand held GPS unit.

2. Garmin MapQuest software.

II. PROCEDURES

A. Procedures described in SOP No. BWM-007 are adopted by reference.

APPENDIX C

STANDARDIZED FIELD AND TAXONOMIC FORMS

FIELD COLLECTION DATA SHEET
FORM APP.C-1

STREAM BIOLOGICAL MONITORING PROGRAM

FIELD COLLECTION FORM

Date________________________ Collector(s)____________________
____
Time:
Beginning____________________
Ending_______________________

Station #____________________

Location____
____

Legal Description: ___,___,___,SEC._____,T_____,R_____

County_______________________________

Temperature: Air__________ Water__________

Dissolved Oxygen Bottle #____________________

Mussel Collection (check)________

Flow Conditions (check one): High (>1' above normal low flow)_____
Normal Low Flow________
Extreme Low Flow_______

Remarks____
____
____
____
____
____
____

HABITAT DEVELOPMENT INDEX FORM
FORM APP.C-2

Habitat Development Index

Stream________________ Station No.________ Date____________

County____________ Legal description________________________

Location ____________________ Evaluator______________

Score only those macro and microhabitat categories that were sampled.

					Riffles	Pools	Runs
MINIMUM MACRO-HABITAT SCORE	Absent 0		Present 3		___	___	___
AVERAGE DEPTHS	Riffles	<5 cm 0	5-10 cm 1	>10 cm 2	___		
	Pools	<30 cm 0	30-60 cm 1	>60 cm 2		___	
	Runs	<15 cm 0	15-45 cm 1	>45 cm 2			___

RIFFLE SUBSTRATE SCORE						
	% Cobble(1)	0-10% 0	11-25% 1	26-50% 2	>50% 3	A
	% Embeddedness	0-25% 0	26-75% -1	>75% -3		B
	Record score in right hand column only if A + B ≥ zero.					A + B ___

	0	1	2	3	Riffles	Pools	Runs
ORGANIC DETRITUS AND DEBRIS (2)	No organic detritus or debris was sampled. 0	Only sparsely scattered bits of detritus were sampled. 1	Large leaf packs or large amounts of scattered detritus were sampled. 2	Both detritus and debris including logs were sampled. 3	___	___	___
ALGAL (3) MASSES	No algal masses were sampled. 0		Algal masses were sampled. 1		___	___	___
MACROPHYTES (4)	No macrophytes were sampled. 0	Very few macrophytes or small patches of plants were sampled. 1	Many macrophytes or large areas of dense growth were sampled. 2		___	___	___
BANK (5) VEGETATION	No bank vegetation was sampled. 0	Only small amounts of thin bank vegetation was sampled. 1	Submerged tree roots or thick bank vegetation was sampled. 2		___	___	___
MACROHABITAT SCORES					___ +	___ +	___
SAMPLE SCORE							

(1) If percent cobble is ≤10% and boulders or bedrock are present, score box A as a 1. Cobble is defined as particles between 6 and 26 cm in diameter.
(2) Organic detritus includes seeds, pods, leaves, small bark, twigs, leaf fragments, may accumulate into piles or packs. Organic debris includes larger sticks, bark, and logs.
(3) Algal masses should be sampled if they provide habitat and not just food.
(4) Macrophytes include floating-leaved, emergent, or submerged aquatic plants.
(5) Bank vegatation includes submerged terrestial plants, tree limbs, and roots.

IDENTIFICATION BENCH SHEET
FORM APP.C-3

KDHE/BEFS

MACROINVERTEBRATE IDENTIFICATION BENCH SHEET

FORM APP.C-3

STATION__________________ STREAM/LOCATION____
DATE COLLECTED________________ DATE EXAMINED_________________ DETERMINED BY____________
COLLECTOR(S)____________________________________ TYPE OF SAMPLE (EFFORT)_________________

KBS CODE #	A #	N #	L #	P #	TOTAL #	KBS CODE #	A #	N #	L #	P #	TOTAL #
COLEOPTERA						MEGALOPTERA					
						ODONATA					
						PLECOPTERA					
DIPTERA											
						TRICHOPTERA					
						CRUSTACEA					
EPHEMEROPTERA											
						GASTROPODA					
						HIRUDINEA					
						OLIGOCHAETA					
						PELECEPODA					
						TURBELLARIA					
HEMIPTERA											
						OTHER					

KBS CODE#=KDHE KANSAS BIOSYSTEM TAXON UNIQUE CODE A#=NUMBER OF ADULTS IN SAMPLE
N#=NUMBER OF NYMPHS IN SAMPLE L#=NUMBER OF LARVAE IN SAMPLE P#=NUMBER OF PUPAE IN SAMPLE

TOT. #_________ TOT. TAXA_______ EPT INDEX______ MBI_________ MBI(N)______ HDI_______ D.O.________

SHEET_____OF_____

LIVE MUSSEL RECORDING FORM
FORM APP.C-4

(Front of Form)

KANSAS DEPARTMENT OF HEALTH AND ENVIRONMENT
BUREAU OF ENVIRONMENTAL FIELD SERVICES
STREAM BIOLOGICAL MONITORING PROGRAM

LIVE UNIONID MUSSEL RECORDING FORM

Date________________________ Collector(s)________________________

Station I.D. #________________ ________________________

Waterbody Description____

Legal Description_____, _____, Sec._____, T_____, R_____ County____________________

Scientific Name	Scarce	Common	Abundant	Multiple Age Classes?
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				

Exotic bivalve species present? Yes_____ If yes, what species?________________________

No_____ ________________________

Remarks____

____

LIVE MUSSEL RECORDING FORM
FORM APP.C-4

(Back of Form)

KANSAS NAIAD REFERENCE LIST

Scientific Name:	Common Name:	Status:
Order Unionoida		
Family Margaritiferidae		
Cumberlandia monodonta (Say, 1829)	spectaclecase	extirpated
Family Unionidae		
Subfamily Anodontinae		
Alasmidonta marginata Say, 1818	elktoe	endangered
Alasmidonta viridis (Rafinesque, 1820)	slippershell mussel	extirpated
Anodonta suborbiculata Say, 1831	flat floater	endangered
Anodontoides ferussacianus (I. Lea, 1834)	cylindrical papershell	SINC
Arcidens confragosus (Say, 1829)	rock pocketbook	threatened
Lasmigona complanata complanata (Barnes, 1823)	white heelsplitter	
Lasmigona costata (Rafinesque, 1820)	flutedshell	threatened
Pyganodon grandis (Say, 1829)	giant floater	
Strophitus undulatus (Say, 1817)	creeper	SINC
Utterbackia imbecillis (Say, 1829)	paper pondshell	
Subfamily Ambleminae		
Amblema plicata (Say, 1817)	threeridge	
Cyclonaias tuberculata (Rafinesque, 1820)	purple wartyback	candidate
Elliptio dilatata (Rafinesque, 1820)	spike	SINC
Fusconaia flava (Rafinesque, 1820)	Wabash pigtoe	SINC
Megalonaias nervosa (Rafinesque, 1820)	washboard	SINC
Pleurobema sintoxia (Rafinesque, 1820)	round pigtoe	SINC
Quadrula cylindrica cylindrica (Say, 1817)	rabbitsfoot	endangered
Quadrula fragosa (Conrad, 1835)	winged mapleleaf	extirpated
Quadrula metanevra (Rafinesque, 1820)	monkeyface	
Quadrula nodulata (Rafinesque, 1820)	wartyback	SINC
Quadrula pustulosa pustulosa (I. Lea, 1831)	pimpleback	
Quadrula quadrula (Rafinesque, 1820)	mapleleaf	
Quadrula quadrula form *nobilis* (Conrad, 1854)	mapleleaf form	extirpated
Tritogonia verrucosa (Rafinesque, 1820)	pistolgrip	
Uniomerus tetralasmus (Say, 1831)	pondhorn	
Subfamily Lampsilinae		
Actinonaias ligamentina (Lamarck, 1819)	mucket	endangered
Cyprogenia aberti (Conrad, 1850)	western fanshell	endangered
Ellipsaria lineolata (Rafinesque, 1820)	butterfly	threatened
Epioblasma triquetra (Rafinesque, 1820)	snuffbox	extirpated
Lampsilis cardium Rafinesque, 1820	plain pocketbook	candidate
Lampsilis rafinesqueana Frierson, 1927	Neosho mucket	endangered
Lampsilis siliquoidea (Barnes, 1823)	fatmucket	SINC
Lampsilis teres (Rafinesque, 1820)	yellow sandshell	SINC
Leptodea fragilis (Rafinesque, 1820)	fragile papershell	
Ligumia recta (Lamarck, 1819)	black sandshell	extirpated
Ligumia subrostrata (Say, 1831)	pondmussel	
Obliquaria reflexa Rafinesque, 1820	threehorn wartyback	
Obovaria olivaria (Rafinesque, 1820)	hickorynut	extirpated
Potamilus alatus (Say, 1817)	pink heelsplitter	
Potamilus ohiensis (Rafinesque, 1820)	pink papershell	
Potamilus purpuratus (Lamarck, 1819)	bleufer	
Ptychobranchus occidentalis (Conrad, 1836)	Ouachita kidneyshell	threatened
Toxolasma parvus (Barnes, 1823)	lilliput	
Truncilla donaciformis (I. Lea, 1828)	fawnsfoot	SINC
Truncilla truncata Rafinesque, 1820	deertoe	SINC
Venustaconcha ellipsiformis (Conrad, 1836)	ellipse	endangered

MUSSEL SHELL ARCHIVAL FORM
FORM APP.C-5

KDHE KANSAS MUSSEL DISTRIBUTION DATABASE PAGE ____ Of ____

ARCHIVE # ________________ BASIN _________ WATERBODY ____________________
BIOLOGICAL STATION # ___________ CHEMICAL STATION # ___________ UAA STATION # ___________
LOCATION ____
LEGAL DESCRIPTION ____________________ COLLECTED DATE ___________ CO. _________
SCIENTIFIC NAME ____________________
COMMON NAME ____________________
RELATIVE ABUNDANCE ____________________ SHELL: CONDITION ____________________
SHELL: HEIGHT ___________ LENGTH ___________ KBS CODE ___________ STATUS ___________
COLLECTED BY ____________________ I. D. BY ____________________
REMARKS: ____

ARCHIVE # ________________ BASIN _________ WATERBODY ____________________
BIOLOGICAL STATION # ___________ CHEMICAL STATION # ___________ UAA STATION # ___________
LOCATION ____
LEGAL DESCRIPTION ____________________ COLLECTED DATE ___________ CO. _________
SCIENTIFIC NAME ____________________
COMMON NAME ____________________
RELATIVE ABUNDANCE ____________________ SHELL: CONDITION ____________________
SHELL: HEIGHT ___________ LENGTH ___________ KBS CODE ___________ STATUS ___________
COLLECTED BY ____________________ I. D. BY ____________________
REMARKS: ____

ARCHIVE # ________________ BASIN _________ WATERBODY ____________________
BIOLOGICAL STATION # ___________ CHEMICAL STATION # ___________ UAA STATION # ___________
LOCATION ____
LEGAL DESCRIPTION ____________________ COLLECTED DATE ___________ CO. _________
SCIENTIFIC NAME ____________________
COMMON NAME ____________________
RELATIVE ABUNDANCE ____________________ SHELL: CONDITION ____________________
SHELL: HEIGHT ___________ LENGTH ___________ KBS CODE ___________ STATUS ___________
COLLECTED BY ____________________ I. D. BY ____________________
REMARKS: ____

ARCHIVE # ________________ BASIN _________ WATERBODY ____________________
BIOLOGICAL STATION # ___________ CHEMICAL STATION # ___________ UAA STATION # ___________
LOCATION ____
LEGAL DESCRIPTION ____________________ COLLECTED DATE ___________ CO. _________
SCIENTIFIC NAME ____________________
COMMON NAME ____________________
RELATIVE ABUNDANCE ____________________ SHELL: CONDITION ____________________
SHELL: HEIGHT ___________ LENGTH ___________ KBS CODE ___________ STATUS ___________
COLLECTED BY ____________________ I. D. BY ____________________
REMARKS: ____

APPENDIX D

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APPENDIX E

GLOSSARY OF TERMS

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accuracy -- the extent to which a measured value actually represents the condition being measured. Accuracy is influenced by the degree of random error (precision) and systematic error (bias) inherent in the measurement operation (e.g., environmental sampling and analytical operations).

activity -- an all inclusive term describing a specific set of operations or related tasks to be performed, either serially or in parallel (e.g., research and development, field sampling, analytical operations), that in total result in a product or service.

audit -- a systematic and independent examination to determine whether quality activities and related results comply with planned arrangements and whether these arrangements are implemented effectively and are suitable to achieve objectives.

bias -- the systematic or persistent distortion of a measurement process which causes errors in one direction (i.e., the degree to which the expected sample measurement is different from the true sample value).

chain of custody -- an unbroken trail of accountability that ensures the physical security of samples, data and records.

comparability -- a measure of the confidence with which one item (e.g., data set) can be compared to another.

completeness -- a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions.

computer program -- a sequence of instructions suitable for processing by a computer. Processing may include the use of an assembler, compiler, interpreter, or translator to prepare the program for execution. A computer program may be stored on electrical, magnetic or optical media.

corrective action -- any measure taken to rectify a condition adverse to quality and, where possible, to preclude its recurrence.

document -- any written or pictorial information describing, defining, specifying, reporting, or certifying activities, requirements, procedures or results.

duplicate samples -- paired samples collected at essentially the same time from the same site and carried through all assessment and analytical procedures in an identical manner. Duplicate samples are used to measure natural variability as well as the precision of a method, monitoring instrument, and/or analyst. More than two such samples are referred to as replicate samples.

D-frame -- a long handled net with an opening in the shape of the capital letter D and a bag mesh size of 0.5 mm.

ecoregion -- an ecologically distinctive geographic area defined in the context of scale by consideration of a combination of landscape characteristics including aspects such as: climate, physiography, soils, vegetation or potential vegetation, geology, and land use.

independent assessment -- a quality assessment of an environmental monitoring program, project or system performed by a qualified individual, group, or organization that is not part of the program, project or system.

internal assessment -- any quality assessment of the work performed by an individual, group, or organization, conducted by those overseeing and/or performing the work.

method -- a body of procedures for performing an activity in a systematic and repeatable manner.

organization -- a company, corporation, firm, enterprise, or institution, or part thereof, whether incorporated or not, public or private, that has its own functions and administration.

performance evaluation -- a type of audit in which the quantitative data generated in a measurement system are obtained independently and compared with routinely obtained data to evaluate the proficiency of a technician, analyst or laboratory.

precision -- the level of agreement among individual measurements of the same property, conducted under identical or similar conditions.

qualified data -- data that have been modified, adjusted or flagged in a data base following data validation and verification procedures.

quality -- those features of a product or service that bear on its ability to meet the stated or implied needs and expectations of the user.

quality assurance (QA) -- an integrated system of management activities involving planning, implementation, assessment, reporting, and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the user.

quality assurance project (program) plan (QAPP) -- a formal document that describes in detail the necessary QA, QC, and other technical activities that must be implemented to ensure that the results of the work performed for the program or project satisfy the stated performance criteria.

quality control (QC) -- the overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that they meet the stated requirements of the user.

quality management plan (QMP) -- a formal document that describes a quality management system in terms of the organizational structure, functional responsibilities, and planning, implementation and assessment of work.

record -- a document or portion thereof furnishing evidence of the quality of an item or activity, verified and authenticated as technically complete and correct. Records may include reports, photographs, drawings, and data stored on electronic, magnetic, optical or other recording media.

reference site -- a stream site which has presettlement condition both within the stream and the stream watershed or a stream site which has much of the character of presettlement conditions such as natural or high quality instream habitat, intact riparian corridor, unusually high proportion of the watershed in continuous vegetative cover and natural aquatic communities. References sites vary with the particular population of streams being considered.

replicate sample -- see duplicate sample.

representativeness -- a measure of the degree to which data accurately and precisely represent a selected characteristic of a monitored system.

reproducibility -- a measure of the degree to which sequential or repeated measurements of the same system vary from one another, independently of any actual change in the system.

standard operating procedure (SOP) -- a written, formally approved document that comprehensively and sequentially describes the methods employed in a routine operation, analysis or action.

surveillance (quality) -- continual or frequent monitoring and verification of the status of an entity (e.g., monitoring program) and the analysis of records to ensure that specified requirements are being fulfilled.

taxa -- (plural of taxon) a species or the lowest practicable level of identification which can be applied to a group of related species.

taxa richness -- a summation of the number of taxa determined as present in a sample.

taxonomy -- the classification of macroinvertebrates according to their established natural relationships

technical review -- a critical review of an operation by independent reviewers collectively equivalent in technical expertise to those performing the operation.

validation -- the establishment of a conclusion based on detailed evidence or by demonstration. This term is often used in conjunction with formal legal or official actions.

verification -- the establishment of a conclusion based on detailed evidence or by demonstration. This term normally implies proof by comparison.